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ATV Test Procedures Manual

Cable Television Transmission Tests

Prepared by the Cable Television Laboratories Inc.

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Overview

Part of the materials in this test procedure are excerpted from the PSWP4-0048 Document titled "Proposed Testing Procedures for Advanced Television Systems, Alternate Media and Broadcast Interface".

The objective of these test procedures is to identify and carry out tests on the key technical and operating parameters required for planning and implementation of Advanced Television (ATV) Systems in the existing cable television system environment. Evaluation is done by simulation of various levels of cable system impairments. Actual simulation is accomplished by the construction of a cable television simulation test system or the cable test bed. The cable television impairments are either generated internally using the cable test bed or introduced into the cable television test system. The level of impairment signal is increased or decreased about the threshold of visibility. The impairing signal is measured. The picture quality of the ATV signal together with the impairing signal are recorded using a digital Video Tape Recorder (VTR) over an impairment range from unwatchable to imperceptible qualities.

Co-channel interference, adjacent channel interference, group delay, differential propagation delay for dual channel systems and channel bandwidth are not included in these cable television test procedures. These parameters are common to both terrestrial broadcast and cable transmission. Please refer to the Broadcast Transmission Tests Manual for these impairments. On the other hand, some test parameters that are specified in the cable test procedures, may be very similar to those in the broadcast test procedures. These test parameters, at Cable Television Laboratories' discretion, may or may not be performed.

The suggested video program test materials used in the cable transmission tests are listed under the test equipment of each section and are similar to those recommended by the FCC-AC Subjective Evaluation Working Party Six.

A Continuous Wave (CW) carrier is often shown on the test equipment setup block diagrams. Its purposes are to provide a reference to set the output power level of the ATV signal under test and to serve as a reference level for the spectrum analyzer display.

The test parameters listed in these test procedures are the recommended list of comprehensive test set. The tests will be performed by Cable Television Laboratories personnel and by a small panel of expert viewers. The expert panel of viewers will base their judgements and opinions on their observations. They are encouraged to identify any abnormalities or peculiarities that exist on a particular ATV system. Behavior of the system at intermediate steps of a parameter, otherwise not specified, in the test plan, resulting in extraordinary indications that do not fall on a smoothed curve between mandated data points shall be fully investigated and reported. Such information shall become an integral part of the test report. Additional tests may be added in an ad hoc basis in an effort to provide more information on the characteristics of the particular ATV system.

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Reference Documents:

--- PS/WP4-0048 Proposed Testing Procedures for ATV Systems Alternate Media and Broadcast Interface.

--- PS/WP4 Proposed Testing Procedures for ATV Systems Suitability for Fiber-Optic Transmission.

--- PS/WP6-0050 February 1988 PS/WP6 Chairman's Report.

1 Discrete Frequency Interference

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1.1 Introduction

Discrete frequency interference is one of the major impairments that exists on cable television systems. There are a variety of sources where discrete frequency interferences originate. These include spurious outputs from headend modulators and processors, ingress from radio services which use the same frequency band as the cable television system and intermodulation products from line equipment. The discrete frequency interference existing in cable systems may be unmodulated, AM modulated or FM modulated. To address the complexity of testing discrete frequency interference, the unmodulated type is chosen in this procedure to test all ATV systems.

1.2 General Description of Method

The discrete frequency interference performance of an ATV system is characterized by coupling a frequency agile R.F. generator to the ATV RF signal. The test is divided into two parts:

1. manual sweep,
2. threshold determination and recording.

The manual sweep identifies any sensitive areas within the ATV channel spectrum. From the manual sweep, any additional frequency steps are noted and a lower limit of the interference signal is established.

For threshold determination, the computer is programmed to follow the sequence as illustrated in the flow chart shown in Figure 1.1. Starting at the lower band edge of the spectrum occupied by the ATV system, the variable RF generator is tuned across the frequency band at a pre-determined step size which is equal to three times the horizontal scan rate.

At each frequency step, the interference RF level is set to the low level limit as determined in subsection 1.4.1. The RF level is increased (or decreased) by 1 dB every 3 seconds until a unanimous agreement among the participating viewers is reached indicating the transition from perceptible to imperceptible (or vice versa). A complete description of the criteria for determining a threshold is described in Appendix A. The perception threshold is calculated and recorded on the computer data base.

The picture quality at each threshold is recorded on tape using a digital VTR. The duration of each tape segment is 1[illegible] seconds. The interference frequency, its output level a[illegible] the SMPTE time code of the corresponding tape segment are stored in the data base. At the end of the test, the stored information is retrieved and printed in a table format showing the interference frequency, the level relative to the ATV carrier and the corresponding SMPTE time code. The data collected on the discrete frequency interference threshold is plotted on a chart with relative carrier-to-interference ratio as a function of interference frequency similar to that of the W-curve for NTSC. A copy of the permissible limits for NTSC signal (published by the Government of Canada, Department of Communications, BP-23 Issue 3) is illustrated in Figure 1.2.

If the ATV system is comprised of a main channel and an augmentation channel, the discrete frequency interference test is conducted on the main channel followed by the augmentation channel.

1.3 Test and Measuring Equipment

Test Material: a color bar test pattern with one area of 20% grey level
RF Generator such as HP 8656B or equivalent
Spectrum Analyzer such as HP 8568B or equivalent
RMS Power Meter
IF-to-Channel 7 upconverter & Channel 7-to-IF downconverter or any other channel as deemed appropriate
Bandpass Filter
    Bandwidth : same as the ATV IF filter.
    Center Freq.: Channel 7
RF switch, two-way splitters and variable attenuators

1.4 Procedures

1.4.1 Manual Sweep

a. Connect the equipment as illustrated in Figure 1.3.
b. Set the injection level to 70 dB below the ATV RF carrier.
c. Slowly tune the variable frequency oscillator across the frequency band of the ATV signal and observe any interference products and note any sensitive areas that may require additional frequency steps.
d. Increase the interference RF level by 3 dB and repeat step c.
e. Note the RF level,T , when the interference becomes just perceptible. The low level limit for the RF generator indicated in Figure 1.1 is equal to (T-5)dB.

1.4.2 Threshold Determination

a. Execute the test measurement by typing "DFRQTH" into the computer.
b. Enter the additional frequency steps as determined by subsection 1.4.1 step c. The computer starts the test sequence at the lower band edge of the

frequency band occupied by the ATV signal.

c. The computer increases the interference level 1 dB every 3 seconds and simultaneously monitors the perception indicators from the viewers. It utilizes the algorithm described in Appendix A to establish and calculate the thresholds. A 10-second recording is made at each threshold.
d. The computer advances the generator to the next frequency step, sets the RF level to the low limit and repeats step c.
e. Measurement is completed when the stop frequency is reached.

1.4.3 Measurement Technique and C/I Computation

When a threshold is established using the algorithm described in Appendix A, the computer measures the Carrier-to-Interference Ratio(C/I) by:

1. setting AT2 (see Figure 1.3) to maximum and recording the power using the RMS power meter. This reading, A, is the Interference + the noise power in the passband.
2. restoring AT2 to the original setting and putting AT1 to maximum and recording the power. This reading, B, is the ATV Signal + the noise power in the passband.
3. setting both AT1 & AT2 to maximum and recording the power. This reading, N, is the noise power in the passband.

The C/I is computed using the following relationships:

Interference + Noise = A in mW
ATV Signal + Noise = B in mW
Noise = N in mW

$$C/I = (B-N)/(A-N)$$

$$C/I \text{ (in dB)} = 10 \log[(B-N)/(A-N)]$$

1.4.4 Presentation of Data

The following data should be recorded:

From the computer data base, plot the C/I perception threshold as a function of frequency.

From the digital VTR, record a 10-second segment of each threshold for the frequency spectrum occupied by the ATV system under test.

From the computer data base, tabulate the interference frequencies, the relative levels of the interference and the corresponding SMPTE time codes.

2 Minimum Carrier-to-Noise (C/N) Requirements

2.1 Introduction

The quality of a television picture is affected by the signal level relative to the noise level. The ratio of signal level and the noise level is called carrier-to-noise ratio (CNR). A high carrier-to-noise ratio usually implies a better picture quality. For AM modulated NTSC signals, a minimum of 40 dB CNR is required for an acceptable picture.

Trunk and distribution amplifiers are the principle source of noise in cable transmission systems because of the additive nature of thermal noise due to amplifier cascade effect.

There are two techniques commonly used to express CNR. The NCTA technique for carrier-to-noise measurement which is widely accepted by the cable television industry, uses 4 MHz as the noise reference bandwidth to express CNR for NTSC signals. The other technique which is becoming more and more popular, normalizes the noise reference bandwidth to 1 Hz. Thus, the expressed CNR is per unit noise bandwidth.

Since the bandwidth occupied by the proponent ATV systems may vary, the second method of expressing CNR is preferred and will be used in this test procedure. In addition, conversion of the measured C/N(1 Hz) ratio to any particular bandwidth is relatively simple. The method of conversion is given in subsection 2.4.3.

2.2 General Description of Method

Noise perceptibility can be determined by coupling a broad band RF noise source to the ATV RF signal. The attenuator at the output of the noise generator in Fig. 2.1 allows level control of the noise output and some noise generators may have an internal attenuator.

The filter used in the equipment setup of Figure 2.1 acts as a preselector. Its function is to limit the measurement bandwidth of the RMS power meter and its bandwidth should equal the IF bandwidth of the ATV system under test.

The test consists of two parts:

1. Noise perceptibility threshold determination, and
2. Ranging Test

To determine the noise perception threshold, the computer is programmed to follow the sequence shown in Figure 2.2.

Starting with a noise level of -136 dB(1 Hz) relative to t! ATV RF signal, the noise level is increased by 1 dB every ɟ seconds until an unanimous agreement among the panel of expert viewers is reached indicating a noise impairment transition from imperceptible to perceptible. The carrier power and noise power are measured and recorded on the data base. The computer then decreases the attenuation until an unanimous agreement is reached indicating a transition from perceptible to imperceptible. The ATV carrier power and noise power are measured and recorded. The cycle is repeated four times. After the completion of the fifth cycle, the data is validated by the computer. A detailed description of threshold determination criteria is given in Appendix A.

The computer sets the attenuator to the calculated threshold to the nearest dB. The ATV signal is temporarily switched off and the noise spectrum displayed on the spectrum analyzer is plotted. The recommended settings for the spectrum analyzer are: reference level to peak of the CW carrier, IF bandwidth 30 kHz, video bandwidth 10 kHz, vertical scale 10 dB per division, frequency span of 10 MHz and sweep time automatic. The ATV signal is restored and AT1 is set to maximum attenuation. The spectrum analyzer settings are the same except IF bandwidth 1 MHz and video bandwidth 1 MHz. The ATV signal spectrum is plotted on the same graph using a pen with a different color.

After establishing the threshold, ranging test can be started. The detailed ranging test is described in Appendix B. The ranging test uses a manual routine. The routine is supervised by a subjective evaluation specialist appointed by the FCC-AC. The equipment setup is identical to that of the threshold determination except that the computer controlled attenuator is replaced by a continuously variable manual operated attenuator.

Under the guidance of the subjective evaluation specialist, the picture quality is intentionally degraded by introducing various level of wideband noise into the ATV signal under test. An upper and a lower boundaries are established. Several intermediate picture quality levels are deduced in a successive manner. The desired number of intermediate steps is nominally between 6 to 9 steps. Each step including the threshold point, upper and lower boundaries is recorded on tape using the digital VTR for a duration of 10 seconds. The tape segments are saved and subsequently be used for subjective evaluation.

If the ATV system consists of a main channel and an augmentation channel, the minimum C/N requirement test should be conducted separately on each channel and then on both channels simultaneously.

2.3 Test and Measuring Equipment

Test Material: 20% flat field of grey
RF Noise Generator such as NC 7108 or 7109
RMS Power Meter
IF-to-Channel 7 upconverter & Channel 7-to-IF downconverter
    or any other channel as deemed appropriate
Spectrum Analyzer such as HP 8568B
Plotter such as HP 7475A
Bandpass Filter
    Bandwidth : same as the ATV IF filter.
    Center Freq.: Channel 7.
Two-way Splitters, RF Switches and Variable Attenuator

2.4 Procedures

2.4.1 Noise Threshold Determination

a. Connect equipment as shown in Fig. 2.1
b. Execute the threshold measurement routine by typing "CNRTHR" into the computer. The computer follows the sequence shown in the Figure 2.2 flow chart.
c. The computer increases the noise level 1 dB every 3 seconds and simultaneously monitors the perception indicators from the viewers. The computer records the noise level once a consensus on perceptible noise is reached.
d. The computer decreases the noise level 1 dB every 3 seconds until a consensus is reached among the expert panel that the noise is no longer perceptible. The noise level is recorded.
e. The cycle described in steps c & d is repeated four times. A detailed description of the threshold determination algorithm is given in Appendix A.
f. The test sequence stops when the five cycles are completed and the data is validated by the computer. The computer calculates the CNR at the threshold and initiates a C/N plot from the spectrum analyzer to the plotter.

2.4.2 Ranging Test

Before the commencement of the ranging test, written instructions are passed out and recorded instructions are played back to expert viewers to ensure thorough understanding of the objective of the ranging test. A detailed description of the ranging test is given in Appendix B of this manual. The ranging test should be conducted under the supervision of a subjective evaluation specialist. The suggested operatior sequence is listed below:

a. Replace the computer controllable step attenuator by the continuously variable attenuator.
b. Set the attenuation of AT1 until the noise level matches the threshold level as determined in subsection 2.4.1 step f.
c. Verify the threshold with the panel of expert viewers. Make a tape recording for a duration of 10-second and note the corresponding SMPTE time code.
d. Increase the attenuation by 3 dB and verify with the panel of expert viewers that the picture quality is free from any external impairments. Make a 10-second recording and note the SMPTE time code.
e. Decrease the attenuation until an unanimous agreement is reached among the panel of expert viewers that the picture quality is not suitable for day-to-day viewing. Make a 10-second recording. Note the SMPTE time code and the corresponding noise impairment level.
f. Establish 6 to 9 intermediate steps by following the instructions given by the subjective evaluation specialist. A suggested method of establishing intermediate steps is outlined in Appendix B.

2.4.3 Measurement Techniques and CNR Computation

The computer measures the C/N(1 Hz) ratio of the ATV system by:

1. Opening SW1 in Figure 2.1 and recording the noise power using the RMS power meter. This is the noise power,A , referenced to the bandwidth of the bandpass filter.

2. Setting AT1 to maximum attenuation and closing SW1 and recording the power using the RMS power meter. This reading is the ATV signal power, B.

   The C/N(1 Hz) ratio is calculated using the following relationships:

   Noise power (ref. to BWIF) = A in dBm
   ATV signal power = B in dBm

   where BWIF is the bandwidth of the bandpass filter used in Figure 2.1.

   $$C/N(1\ \text{Hz}) = B - A + 10\log(\text{BWIF})$$

The measured C/N(1 Hz) ratio can be easily converted to any particular reference bandwidth:

C/N (ATV System) = C/N(1 Hz) - 10 log(BW)

where BW is the occupied bandwidth of the ATV system under test.

2.4.4 Presentation of Data

The following data should be recorded:

From the plotter, plot the ATV signal spectrum and the noise spectrum at the perception threshold on the same graph using different colors of ink. In addition, indicate the measured C/N(1 Hz) ratio on the graph.

From the specifications supplied by the bandpass filter manufacturer, make a copy the frequency response and group delay of the bandpass filter used in this test.

From the digital VTR, record the lower and upper boundaries, the threshold point and the intermediate steps as determined in subsection 2.4.2. Each tape segment has a duration of 10 seconds.

From the computer data base, tabulate the SMPTE time code of each tape segment and the corresponding level of noise impairment in dB.

3 Intermodulation Distortion

3.1 Introduction

Intermodulation distortion is a form of interference resulting from the generation of beats between two or more signals. As signals are processed through amplifiers and other active devices having non-linear characteristics, intermodulation distortions are introduced. Intermodulation distortion products manifest themselves in the form of clusters of beats.

The generation of intermodulation products is given by

$$n_1 f_1 \pm n_2 f_2 \pm n_3 f_3 \pm \cdots$$

where f_x = frequency of a signal
n_x = the harmonic number of f_x

The sum of n_x involved in the frequency formula above gives the order number for the product. Thus,

$f_1 + 2 f_2$ is a (1+2) or 3rd order intermodulation product;
$f_1 + f_2$ is a 2nd order intermodulation product.

In general, low order intermodulation products are the strongest with second and third order intermodulation products being most significant. Third order intermodulation products build up at video carrier frequency and dominate in push-pull amplifiers. Second order products have an offset of +1.25 MHz with respect to video carrier frequency and dominate in single-ended amplifiers. The permissible limit for third order intermodulation products is -53 dB for NTSC signals.

3.2 General Description of Method

Intermodulation distortion effects are created by using a cable channels generator which simulates a 60-channel cable system. As shown in Figure 3.1, the generator output is transmitted through a few cable television trunk amplifiers at a level high enough to produce the desired second and third order intermodulation products. The amplified signals are then fed to a narrow bandpass filter. The function of the filter is to select the kind of intermodulation products. Only one filter is used at a time but two filters are required for the tests: one for the selection of second order intermodulation products and the other for third order products. The output level of the intermodulation distortion is controlled by the variable attenuator, AT1. The distortion products and the ATV signal are passively combined and fed to the ATV demodulator or a spectrum analyzer.

The ATV signal is transmitted using either channel 7 or channel 8. There are a few reasons for this choice of channels. Channels 2 through 4 are not used since the number of third order intermodulation products fall within these channels is relatively small. Channels 5 and 6 are also not used because they are 4 MHz offset from the 6 MHz spacings of the other channels. Mid-band channels, 14 to 22, are not used as these frequencies are allocated to over-the-air mobile radio communications. Any shielding problem with the Intermodulation Test setup may have ambiguity observations. The choice between channels 7 or 8 depends on which one is not being used for television transmission in the area where the tests are conducted.

The test consists of four parts:

1. Threshold determination (2nd order),
2. Ranging Test (2nd order),
3. Threshold Determination (3rd order), and
4. Ranging Test (3rd order).

Before commencement of the intermodulation distortion tests, the output power of the ATV signal is set up according to the proponent's specification using the CW carrier as a reference. The attenuator, AT1, is adjusted so that the interfering products are at least 70 dB below the level of the ATV signal.

Starting at this level, the computer decreases the attenuation of AT1 by 1 dB every 3 seconds until an unanimous agreement among the expert viewers is reached that perceptible distortion can be observed on the ATV picture. The computer records the attenuator setting of AT1 and then increases the attenuation of AT1 by 1 dB every 3 seconds until an unanimous agreement among the expert viewers is reached that intermodulation distortion is no longer visible. The computer again records the attenuator setting. The cycle is repeated four times.

After the completion of the fifth cycle, the data is validated by the computer. The computer sets the attenuator to the calculated threshold to the nearest dB. The ATV signal is temporarily switched off using SW2 and the interfering products displayed on the spectrum is measured and plotted. The recommended settings for the spectrum analyzer to measure the interference products are: reference level to peak of CW carrier, IF bandwidth 30 kHz, video bandwidth 10 Hz, vertical scale 10 dB per division, frequency span of 500 kHz and sweep time 0.2 second. The ATV signal is restored and AT1 is set to maximum attenuation for a plot of the ATV signal spectrum. The recommended settings for the spectrum analyzer are the same except that IF bandwidth and video bandwidth are set to 1 MHz. The two plots are done on the same piece of paper and each plot is drawn with a different color of ink. A detailed description of the methodology for threshold determination i given in Appendix A.

The ranging test equipment setup is identical to that of the threshold determination except that the computer controlled attenuator is replaced by a continuously variable attenuator.

Under the guidance of the subjective evaluation specialist, the picture quality of the ATV signal is intentionally degraded by introducing various level of intermodulation products. An upper boundary, a lower boundary and several intermediate steps are established. Each step including the threshold point, upper and lower boundaries is recorded on tape using the digital VTR for a duration of 10 seconds. The tape segments are saved for archival. A detailed ranging test algorithm is described in Appendix B.

The procedure for testing composite second order and composite third order is identical except that the narrow bandpass filter used for selecting composite second order distortions is different from the one for selecting composite third order. After the completion of the composite second order distortion test, the narrow bandpass filter is replaced with the one that selects the composite third order products and the complete procedure is repeated.

If the ATV system consists of a main channel and an augmentation channel, the intermodulation distortion tests should be conducted separately on each channel and then on both channels simultaneously.

3.3 Test and Measuring Equipment

CATV trunk amplifiers
Cable Channels Generator
Spectrum Analyzer such as HP 8568B or equivalent
Plotter such as HP 7475A or equivalent
IF-to-Channel 7 upconverter and Channel 7-to-IF downconverter
    or any other channel as deemed appropriate
Narrow Bandpass Filters
    Bandwidth : 750 kHz
    Center Frequency: 175.25MHz (2nd order) & 176.50MHz (3rd)
Two-way Splitters, RF Switches and Variable Attenuator

3.4 Procedures

3.4.1 Threshold Determination

a. Connect the equipment as shown in Fig. 3.1 and use the narrow bandpass filter which selects the second order intermodulation products for the equipment setup.
b. Enter "IMODTHR" into the computer to execute th threshold determination program. The computer

follows the sequence shown in the Figure 3.2 flow chart.

c. The computer decreases the attenuation of AT1 by 1 dB every 3 seconds and simultaneously monitors the perception indicators from the viewers. The computer records the attenuator setting of AT1 once a consensus on perceptible distortion is reached.
d. The computer increases the attenuation of AT1 by 1 dB every 3 seconds until a consensus is reached among the panel of expert viewers that intermodulation distortion is no longer visible. The attenuator setting of AT1 is recorded.
e. The cycle described in steps c & d is repeated four times.
f. The test sequence ends when the five cycles are completed and the data is validated by the computer. The computer calculates the level of intermodulation distortion at the threshold and initiates a plot of the intermodulation distortion at threshold.
g. Replace the narrow bandpass filter with the one that selects the composite third order products and repeat the complete procedure starting at step b.

3.4.2 Ranging Test

The suggested operational sequence of the ranging test is listed below:

a. Replace the computer controllable step attenuator by a continuously variable attenuator.
b. Connect the narrow bandpass filter which selects the second order intermodulation products to the test setup.
c. Set the attenuation of AT1 to the threshold value as determined in the threshold test and verify the threshold with the panel of expert viewers.
d. Increase the attenuation of AT1 by 3 dB and verify with the panel of expert viewers that the picture quality is free from any external impairments.
e. Decrease the attenuation until an unanimous agreement is reached among the panel of expert viewers that the picture quality is not suitable for day-to-day viewing.
f. Note the SMPTE time code, and the corresponding intermodulation distortion level.
g. Establish 6 to 9 intermediate steps by following the instructions given by the subjective evaluation specialist. A suggested method of establishing intermediate steps is outlined in Appendix B.
h. Replace the narrow bandpass filter with the one that selects the composite third order products and repeat the complete procedure starting at step c.

3.4.3 Presentation of Data

The following data should be recorded:

From the digital VTR, record the lower and upper boundaries, the threshold point and the intermediate steps as determined in subsection 3.4.2. Each tape segment has a duration of 10 seconds.

From the computer data base, tabulate the SMPTE time code of each tape segment and the corresponding level of second or third order intermodulation products in dB.

From the plotter, plot the ATV signal spectrum and the second order intermodulation products spectrum at threshold on the same graph using different colors of ink. Indicate on the graph the difference between the levels of the ATV signal and the intermodulation products in dB. Repeat the same with third order intermodulation products.

4 Effect of Microreflections

4.1 Introduction

Signal reflections occur throughout coaxial cable television transmission systems and are caused by impedance mismatches between cables and other system components such as amplifiers, passive devices, connectors and splices. Reflections on NTSC signals can cause three different subjective effects. For reflections having delays longer than 500 ns, a distinct second image or "ghost" in the picture background can be identified. At around 250-500 ns, an apparent increase or decrease in signal contrast can be observed. The increase or decrease in signal contrast depends on the relative phase of the reflected signal with respect to the carrier frequency. Reflections with delays less than 250 ns show a chrominance saturation change and a small amount of luminance level change.

The purpose of the following procedure is to introduce reflections to the ATV system under test. Observations are made on the perception thresholds with respect to various delays. The procedure is structured for single reflection.

4.2 General Description of Method

Reflection effects are generated by delaying the main signal using various lengths of cable with delays of 10, 20, 40, 80, 160, 320, 640, 1280, 2560 nanoseconds.

The test consists of two parts:

1. single reflection which consists of nine individual delays, and
2. ranging test for the nine delays.

Individual delay signals are created by splitting the main ATV signal into two paths. One path has no delay. The other path has a delay line, a sliding line and a variable attenuator in cascade. The amplitude and phase of the delay signal are controlled by the variable attenuator and the sliding line respectively. The two signals are re-combined to create the reflection effect (see Figure 4.1).

The computer is programmed to follow the sequence shown in Figure 4.2. A delay line is connected to the test setup. An entry of a low level limit of attenuation for the delay signal is optional. However, the default low limit is -50 dBc and it is left to the expert viewers' discretion to input a different low level limit which is higher than -50 dBc.

After the low limit level is entered, the computer starts increasing the delay signal level by 1 dB every 3 seconds until an unanimous agreement among the expert viewers has reached indicating that perceptible impairment is observed on the ATV picture. The computer sequence is manuall· interrupted. The sliding line which is connected in cascade to permit carrier phase adjustment is tuned for the position with the most noticeable impairment.

The sequence is resumed and the attenuation of AT1 is increased gradually until reflection impairment is no longer visible. The relative level of the delayed signal is recorded by the computer and stored in its data base. The computer then decreases the attenuation until an unanimous agreement is reached indicating a transition from imperceptible to just perceptible. The relative level of the delayed signal is recorded. The cycle is repeated four times.

After the completion of the fifth cycle, the data is validated by the computer. The perception threshold is calculated and recorded on the computer data base. The recorded reading gives a measure of the corresponding carrier-to-echo ratios in units of dB. The collected data is saved and is used at a later time to plot a graph with carrier-to-echo ratio as a function of delay times. The same procedure is repeated for the remainder of the eight delay lines. A detailed description of threshold determination criteria is given in Appendix A.

After thresholds are found and threshold data is taken for the individual delay lines, ranging tests are conducted separately on the nine delays. A detailed description of how to carry out the ranging test is given in Appendix B. The ranging test uses a manual routine. The equipment setup is identical to that of the threshold determination except that the computer controlled attenuator is replaced by a continuously variable manual operated attenuator.

Under the guidance of the subjective evaluation specialist, an upper boundary, a lower boundary and several intermediate picture quality level are deduced in a successive manner. The desired number of intermediate steps is nominally between 6 to 9 steps. Each step including the threshold point, upper and lower boundaries are recorded on tape using the digital VTR for a duration of 10 seconds. The tape segments are saved and subsequently be used for subjective evaluation.

It is recommended that reflections with the longest delay be carried out first as close-in reflections are difficult to discern. Beginning with the longest reflection permits the viewers and operating technician to undergo the learning process of distinguishing distortion caused by reflections with delays gradually diminishing.

If the ATV system under test utilizes an augmentation channel, the microreflection test should be conducted separately on the main channel only, the augmentation channel only and then on both channels simultaneously.

4.3 Test and Measuring Equipment

Test Material: Black and white text and color text with well defined edges. (matrix test pattern consisting a combination of multiburst, color bars, crosshatch and resolution charts.)

A sliding line which provides continuous phase shift up to 360°

IF-to-Channel 3 upconverter and Channel 3-to-IF downconverter or any other channel as deemed appropriate

Variable attenuators

Delay Lines

4.4 Procedures

4.4.1 Single Reflections

a. Connect the equipment as shown in Fig. 4.1
b. Start the program by typing "MREFTHR" into the computer.
c. Connect the selected delay line to the test setup and enter the low level limit of the delay signal if desired. The computer decreases the attenuation of AT1 by 1 dB every 3 seconds.
d. Observe the presence of any impairments caused by reflection and interrupt the computer routine by pressing the "SPACE BAR".
e. Adjust the sliding line for the most noticeable impairment and resume the automated sequence by pressing the "ESCAPE" key.
f. The computer increases the attenuation of AT1 by 1 dB every 3 seconds until a consensus is reached among the expert panel that the reflection is no longer visible. The attenuator setting is recorded.
g. The computer decreases the attenuation of AT1 by 1 dB every 3 seconds and simultaneously monitors the perception indicators from the viewers. The computer records the attenuator setting once a consensus on perceptible reflection is reached.
h. The cycle described in steps f & g is repeated four times.
i. The test sequence stops when the five cycles are completed and the data is validated by the computer. The computer calculates the threshold at this particular delay.
j. Repeat step b through step i to determine threshold levels for each of the nine delay lines.
k. A graph is plotted using carrier-to-echo ratio as a function of delay times.

4.4.2 Ranging Test

The suggested operational sequence is listed below:

a. Replace the computer controllable step attenuator by the continuously variable attenuator.
b. Connect the selected delay line to the test setup.
c. Set the attenuation of AT1 to the threshold value as determined in subsection 4.4.1 step i of the threshold test and verify the threshold with the panel of expert viewers.
d. Increase the attenuation of AT1 by 3 dB and verify with the panel of expert viewers that the picture quality is free from any external impairments.
e. Decrease the attenuation until an unanimous agreement is reached among the panel of expert viewers that the picture quality is not suitable for day-to-day viewing.
f. Note the SMPTE time code, and the corresponding reflection impairment level.
g. Establish 6 to 9 intermediate steps by following the instructions given by the subjective evaluation specialist. A suggested method of establishing intermediate steps is outlined in Appendix B.

4.4.3 Presentation of Data

The following data should be recorded:

From the digital VTR, record the range of steps that are established by the ranging test for each delay with a duration of 10 seconds each.

From the computer data base, plot a graph with carrier-to-echo ratio as a function of delay times.

From the computer data base, tabulate the SMPTE time code of each tape segment, the level of reflection impairment in dB and the corresponding delay time.

5 Effect of High Level Sweep

5.1 Introduction

High level sweep equipment is commonly used by cable operators to conduct preventive maintenance and audits on trunk and distribution plants. It provides a convenient way of observing the frequency response of a cable system at all frequencies to ensure optimum performance. A high level sweep system consists of a transmitter and a receiver. The transmitter is an electronically tuned RF signal source which is capable of tuning through the complete cable TV spectrum. The transmitter is installed at the cable TV headend and is coupled into the input of the first amplifier. The level of the transmitter sweep output is normally +10 dB relative to the television video carrier levels. The repetition rate can range from 5 to 10 seconds. Each sweep duration is about 1 millisecond. The receiver is synchronized to the transmitter sweep signal via the pilot carrier generated by the transmitter. The effect of disturbance created by the high level sweep on NTSC signals is very small due to its short duration and relatively long repetition rate. However, it may be of interest to check the effect of high level sweep on the ATV system under test as the sweep signal is known to create errors on data transmission.

5.2 General Description of Method

The sweep transmitter is passively combined with the ATV signal under test. The sweep width of the transmitter is adjusted to cover both the main channel and the augmentation channel where applicable. The output level of the transmitter is set to nominal operating level and subsequently +3 dB relative to the nominal level. Observations are made on the severity of picture degradation such as corruption of data, interference to the ATV picture or sound and loss of synchronization for the two transmitter output signal level conditions. The picture degradations are recorded on tape for archival.

5.3 Test and Measuring Equipment

Cable Sweep System Transmitter such as Wavetek 1855
Spectrum Analyzer such as HP 8568B or equivalent
RMS Power Meter
IF-to-Channel 7 upconverter & Channel 7-to-IF downconverter
    or any other channel as deemed appropriate
Bandpass Filter
    Bandwidth : same as the ATV system IF bandwidth.
    Center Freq.: channel 7
RF Switches and Variable Attenuators
Three-way and Two-way Splitters

5.4 Procedures

5.4.1 Setup and Recording

a. Connect the equipment as illustrated in Figure 5.1.
b. Measure the power output of the ATV signal to ensure that the level output is the same as specified by the proponent system. The CW carrier may be used as a power reference.
c. Set the sweep width to cover the complete bandwidth from 50 to 550 MHz and a repetition rate of 5 seconds.
d. Set the output level of the sweep transmitter to +10 dBc with respect to the CW carrier.
e. Note the severity of picture degradation and audio distortions.
f. If the ATV system fails to recover within 5 seconds, change the repetition rate to 10 seconds.
g. Record the ATV picture for 10 seconds using the digital VTR.
h. Repeat step e & step g after setting the sweep transmitter output level to +13 dBc.

5.4.2 Presentation of Data

The following data should be recorded:

From the observations of the test, note any concerns or comments regarding the effect of the high level sweep signal on the video and audio of the ATV system under test.

From the digital VTR, record the ATV signal with a +10 dBc and +13 dBc level of sweep outputs each with 10 seconds duration.